CLAIMS

1. A method for fabricating a bi-layer photovoltaic cell, comprising:

mixing a plurality of p-type nanocrystalline semiconductors in a first binder matrix;

forming a thin p-layer comprising the mixed p-type nanocrystalline semiconductors and the first binder matrix;

mixing a plurality of n-type nanocrystalline semiconductors in a second binder matrix;

forming a thin n-layer comprising the mixed n-type nanocrystalline semiconductors and the second binder matrix; and

binding the p-layer and the n-layer to establish contact between at least a portion of the n-type nanocrystalline semiconductors and the p-type nanocrystalline semiconductors at a p-n heterojunction interface.

2. The method of claim 1, wherein the p-type mixing further comprises mixing in a plurality of anion additives and wherein the n-type mixing further comprises mixing in a plurality of cation additives, whereby during the binding uncompensated anions are produced proximal to the interface in the p-layer and uncompensated cations are produced proximal to the interface in the n-layer.

3. The method of claim 2, further including processing the bound p-layer and n-layer to remove mobile counter ions at the p-n heterojunction interface.

4. The method of claim 1, wherein the binder matrices comprise an epoxy and binding is performed prior to final stages of curing the epoxy.

5. The method of claim 4, wherein the binding includes applying heat and pressure to the contacting p-layer and n-layer.

6. The method of claim 1, wherein the forming of the p-layer further comprises applying the thin p-layer to a flexible electrically conductive substrate and the forming of the n-layer further comprises applying the thin n-layer to a flexible electrically conductive substrate.

7. The method of claim 1, wherein the p-layer and the n-layer have thicknesses less than about 250 nanometers.

8. The method of claim 7, wherein the p-type nanocrystalline semiconductors and the n-type nanocrystalline semiconductors comprise single organic crystals less than about 150 nanometers in size.

9. The method of claim 8, wherein the p-type nanocrystalline semiconductors comprise p-type TiOPc crystals and the n-type nanocrystalline semiconductors comprise n-type PPyEI crystals.

10. A product comprising at least one bi-layer photovoltaic cell formed according to the method of claim 1.

11. A bi-layer photovoltaic cell, comprising:

a first semiconductor layer comprising a binder, nanocrystals of an n-type semiconductor, and a plurality of spatially bound cations;

a second semiconductor layer contacting the first semiconductor layer comprising a binder, nanocrystals of a p-type semiconductor, and a plurality of spatially bound anions; and

a p-n heterojunction at the contacting interface between the first and second semiconductor layers, wherein the spatially bound cations and anions are proximal to the p-n heterojunction.

12. The cell of claim 11, further including a first electric contact attached to the first semiconductor layer distal to the p-n heterojunction and a second electric contact abutting the second semiconductor layer distal to the p-n heterojunction.

13. The cell of claim 11, wherein the n-type and the p-type nanocrystals are smaller than about 150 nanometers and comprise organic crystals.

14. The cell of claim 11, wherein the binders comprise a polymer matrix.

15. The cell of claim 14, wherein the polymer matrix comprises an epoxy.

16. The cell of claim 11, wherein the nanocrystals of a n-type semiconductor comprise a portion of the volume of the first semiconductor layer larger than a portion of the volume of the first semiconductor layer comprising the binder and wherein the nanocrystals of a p-type semiconductor comprise a portion of the volume of the second semiconductor layer larger than a portion of the volume of the second semiconductor layer comprising the binder.

17. A method of producing a bi-layer organic photovoltaic cell, comprising:

forming a p-layer comprising organic nanocrystals of a p-type semiconductor, a binding matrix, and an anion additive;

forming an n-layer comprising organic nanocrystals of an n-type semiconductor, a binding matrix, and a cation additive;

binding the p-layer and the n-layer to create a p-n heterojunction interface between abutting portions of the p-type semiconductor organic nanocrystals and the n-type semiconductor organic nanocrystals.

18. The method of claim 17, wherein the p-type semiconductor organic nanocrystals comprise greater than about 60 percent of the volume of the p-layer and the n-type semiconductor organic nanocrystals comprise greater than about 60 percent of the volume of the n-layer.

19. The method of claim 17, wherein the anion additive is substantially uniformly dispersed in the p-layer and comprises a first salt and wherein the cation additive is substantially dispersed in the n-layer and comprises a second salt.

20. The method of claim 19, wherein the first salt comprises glycerol-2-phosphate, sodium salt and the second salt comprises triethanoloamine quaternized with 1-bromobutane.

21. The method of claim 17, further comprising prior to the binding of the p-layer and the n-layer, expelling a plurality of a first mobile ion produced during the p-layer forming from the p-layer and a plurality of a second mobile ion produced during the n-layer forming from the n-layer to set an interfacial potential of the p-n heterojunction interface.

22. The method of claim 17, further comprising during the binding of the p-layer and the n-layer, removing at least a portion of volatile mobile ions generated in the n-layer or the p-layer.

23. The method of claim 22, wherein the removing of the volatile mobile ions is performed under reverse electrical bias.

24. The method of claim 17, wherein the p-layer has a thickness of less than about 250 nm and the n-layer has a thickness of less than about 250 nm.

25. The method of claim 24, wherein the p-type semiconductor organic nanocrystals comprise titanyl phthalocyanine (TiOPc) and the n-type semiconductor organic nanacrystals comprise perylene-bis-2-pyridylethylimide (PPyEI) each having a size less than about 150 nm.

26. The method of claim 17, wherein the binding matrices comprise epoxy and the binding of the p-layer and the n-layer is performed prior to curing of the epoxy.

27. The method of claim 17, further comprising providing a first electrically conductive substrate abutting the p-layer on a side opposite the p-n heterojunction and providing a second electrically conductive substrate abutting the n-layer on a side opposite the p-n heterojunction

28. The method of claim 17, wherein the p-layer further comprises inorganic nanocrystals of a p-type semiconductor.

29. The method of claim 17, wherein the n-layer further comprises inorganic nanocrystals of an n-type semiconductor.

30. The method of claim 17, further comprising after the binding, dehydrating the bound p-layer and n-layer in a vacuum oven at a raised temperature.

31. The method of claim 17, wherein the binding matrix of the p-layer comprises the anion additive or the binding matrix of the n-layer comprises the cation additive.

32. The method of claim 17, wherein the anion additive is incorporated into the p-type semiconductor organic nanocrystals or the cation additive is incorporated into the n-type semiconductor organic nanocrystals.

33. A power window comprising a cell formed by the method of claim 17, wherein the p-type semiconductor organic nanocrystals, the n-type semiconductor organic nanocrystals, the binding matrices, the anion additive, and the cation additive are substantially transparent.